own physiological activities a constant temperature. As for instruments to measure relative humidity, it is sufficient to say that these instruments do not indicate the conditions they are designed to measure as accurately as they should. Together with temperature and relative humidity, bodily comfort is also affected by air movement, or, reducing the whole matter, we may say that the loss of heat from the body to the atmosphere in general and air movements which remove the saturated and heated air and supply cooler and drier air are the conditions which affect bodily comfort.

As early as 1826, Dr. Heberden (1) suggested that observation of the rate of fall of a thermometer, previously heated, would furnish data for the computation of bodily comfort. He heated a thermometer to 100° F. and noted the number of degrees which it fell in 10 minutes as a measure of "sensible cold."

In 1875 Prof. J. W. Osborne introduced an apparatus which involved a wet cylinder of paper containing warm water as a quantitative measure. Mr. A. Piche, brought forward a similar instrument which he called a *deperditometer* (2). He measured the amount of gas necessary to maintain the water at body heat, the gas being regulated automatically. Prof. J. R. Milne's "constant temperature" *psuchrainometer* (3) was introduced in 1911 and was soon followed by his "constant energy" type of the same instrument. Electrical heating and measurements were used. He deduced an empirical formula giving the rate of cooling as a function of temperature and wind velocity.

In 1911, Dr. F. Frankenhäuser (4) introduced an instrument called the *homæotherm* for measuring the cooling effect of temperature, moisture, wind, solar radiation, etc. It consisted of a small copper cylinder filled with water in which was plunged a thermometer. It was so designed that a fall of one degree centigrade corresponded to the loss of one gram calorie. Various thicknesses of different textiles were wrapped around the cylinder to approximate more closely the environment of the body. It was noted that an increase in wind velocity had a more marked effect than a sharp fall in temperature.

Prof. Leonard Hill introduced two instruments; one, the *caleometer* devised in collaboration with Prof. O. W. Griffith, consists of a small electrical furnace automatically kept at body temperature and working on much the same principle as instruments of the same class already mentioned. The other invention is the *katathermometer* (5) and was first described by the inventor in 1913.

The katathermometer outfit consists of two specially constructed thermometers with large bulbs and stems graduated from 86° to 110° F., one to be used as a dry and the other as a wet bulb thermometer. The bulbs are heated by means of hot water to a temperature of about 110° and place in clips which hold them in a horizontal position, after drying the one and removing the excess moisture from the other. The time taken for each thermometer to fall from 100° to 90° F. is observed by means of a stop watch and these readings serve as values to be transformed into an index representing the cooling effect of the air immediately surrounding the body.

On an ideal spring day the wet has been found to take 45 seconds and the dry 2 minutes 20 seconds. Under any conditions the maximum time for the wet sould be 1 minute and the dry 3 minutes. Factors have been determined for each thermometer so that the rate of cooling can be expressed in milli-calories per square centimeter per second. The rate of fall of both thermometers will be affected by air movement and radiant heat as well as by air temperature, and the wet bulb will also be affected by the humidity. An extended series of experiments was made by Prof. C.-E. A. Winslow (6) of the Yale Medical School, using this apparatus.

Three series of experiments were made under varying conditions, the results in each case being compared with the vote of from three to twenty observers, who expressed their opinion on an arbitrary scale as follows: 1, cold; 2, cool; 3, ideal; 4, warm; 5, hot. The deductions drawn show that although the katathermometer appears to be unduly influenced by air movement, "it seems clear that this instrument is of great value in measuring the actual influence of air conditions upon the body and is greatly superior to the ordinary thermometer for this purpose."

Messrs. Hill, Griffith, and Flack have published an important contribution (7) in which the readings are expressed in the fundamental units of milli-calories per square centimeter.

Empirical formulas have been deduced for the measurement of heat loss as follows:

For the dry kata— $H=(0.27+0.49\sqrt{V})(T-t)$.

For the wet kata— $H'=(0.27+0.49\sqrt{V})(T-t)+(0.085+0.102V^{0.3})\ (F-f)^{4/3}$

where H, H' are the heat losses from the dry and wet katas, respectively, in milli-calories per square centimeter per second, V is the wind velocity in m. p. s., T is the katatemperature (36.5° C.), t is the air temperature (° C.), F the saturation vapor pressure at 36.5° C. (45.4 mm.), and f is the vapor pressure of the air.

Mr. C. W. B. Normand (8) has recently published an extensive article in which he discusses what he calls the "upper climatic limit." In this discussion is a good account of the katathermometer with several graphs. He finds that for ordinary conditions the wet kata is very suitable but, under those conditions of temperature, air movement and humidity which tend to make life cease, he finds that a large-bulbed wet thermometer is more desirable.

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THE SCIENCE OF VENTILATION AND OPEN-AIR TREATMENT.

By Dr. LEONARD HILL.[1]

The British Medical Research Council has just issued, under the title of "The Science of Ventilation and Open Air Treatment," a very commendable study upon the important relations between atmospheric conditions, health and comfort. The work of Dr. Leonard Hill on

[1] The Italian Government has conferred upon Dr. Leonard Hill, F. R. S., the Italian silver medal "Ai Benemeriti della Salute Publica." (Science, New York, Oct. 15, 1920, p. 358.)

(To face p. 498.

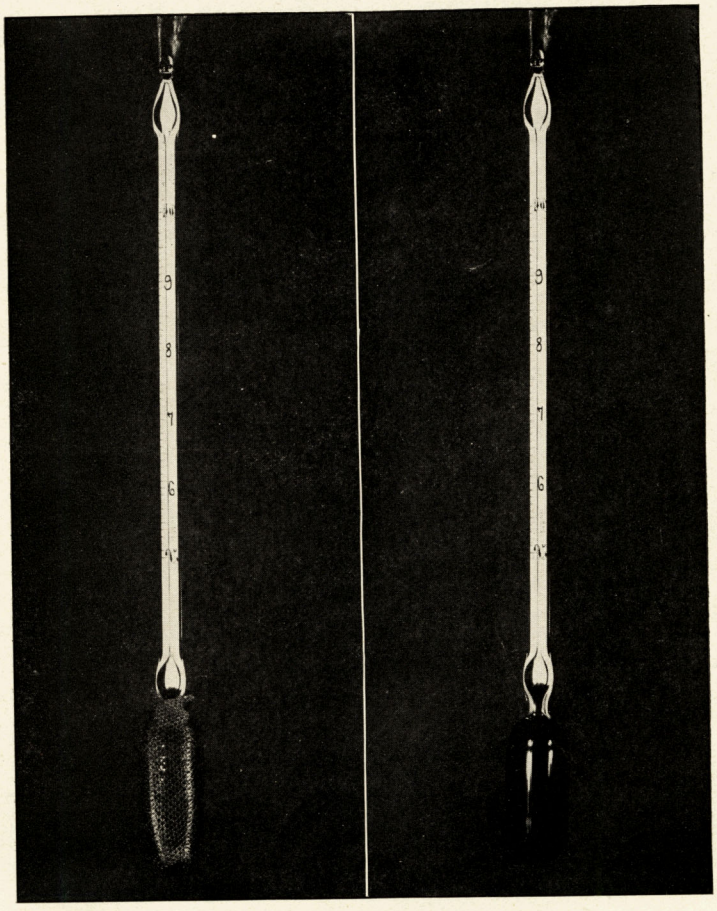

FIG. 1.—Wet and dry katathermometer.

some of the uses of the katathermometer have been discussed before.[2] There is such a great mass of material presented in the two volumes, which constitute the two parts of the work, that it affords a very prolific source of information for those who are interested in this subject.

Some of the chapter headings from the two parts will serve to indicate in a general way the nature of the material and the discussion. In Part I we find: The cooling power of the atmosphere and its measurement by the katathermometer; the conductivity of the skin and heat-loss in relation to surface and deep temperature; the influence of the atmospheric environment on the respiratory membrane; records of observations in numerous places under varied conditions such as cool, sunny, and close days in Egypt, army huts, tents, school rooms, playgrounds, etc.

Part II deals with the chemical purity of the air, radiant energy, sunlight and pigment, heat-stroke, clothes, ventilation and heating of dwellings and work rooms, housing, sickness, and mortality, and open-air treatment.—*C. L. M.*

[2] Atmospheric Conditions which Affect Health, *Quar. Jour. Royal Meteorological Soc.*, July, 1919, pp. 189-207. Abstract reprinted from *Science Abstracts* in Mo. Weather Rev., Nov. 1919, p. 810. Also review by Ellsworth Huntington in *The Geographical Review*, April-June, 1920, pp. 362-363.

CLIMATE AND ITS RELATION TO ACUTE RESPIRATORY CONDITIONS.

By Lt. Col. ESTES NICHOLS, M. D.

[Excerpts from paper read at the meeting of the American Climatological and Clinical Association, at Atlantic City, N. J., June 17, 1920.]

Following the last three years, 1917–18–19, during which time we have experienced a remarkable prevalence of acute respiratory diseases not previously met and studied to such an extent by this generation of observers and in reviewing many reports from all parts of the world, we frequently note reference as to the causation of epidemic bronchitis, influenza and pneumonia and their relation to certain meteorological conditions which, if not held responsible for them, are indicated as having a great influence upon the spread or the sudden termination of these diseases. As these references are made by the most serious writers, it seems necessary for us as climatologists to study carefully every meteorological condition that may have any bearing on such a formidable disease as influenza and pneumonia.

What were the unusual weather conditions, if any, prevailing to account for this most serious bacterial attack upon the human race? For instance, a medical writer in Spain states: "After the subsidence of the epidemic of influenza in Spain last spring, the summer was extremely dry, the drouth being worse than even the oldest inhabitants could remember, and the epidemic flared up again in a much severer form, and the disease, which first seemed to yield to the extreme hot weather, suddenly spread throughout the whole of Spain."

Another writer, from the Philippines, states that "The disease ravaged in the islands for about six weeks, when a typhoon with torrential rain followed by strong winds swept away the last vestige of the disease."

Baccarini is inclined to believe that the germs causing it had their virulence suddenly enhanced by some mysterious influence, electric, atmospheric, or telluric. Another writer states "The epidemic appeared after a very hot season had suddenly been succeeded by a very cold one and that perhaps the weather precipitated a large amount of other respiratory infections such as always become prevalent at this season (autumn)." This is answered by many other writers who state that this pandemic differs from that of 1890 and 1892 in that acute nasal catarrh and sinus involvement were conspicuous by their absence this year. It is also said that among the causes which contributed to the high incidence of influenza-pneumonia in the American Expeditionary Forces were working and sleeping in wet clothes and shoes, eating of food served cold, insufficient blankets for warm sleeping during the wet, cold period in northern France, yet several exhaustive reports of the incidence of influenza-pneumonia among troops stationed in barracks and tents in this country show that the weather conditions when the epidemic struck were unsurpassed; no rain, not cloudy, fair and warm—the weather being all that one could wish for the troops occupying tents, and that a long period of fine weather followed the onset of the pandemic. In letters sent out by a medical association for the prevention of disease, a slip was inclosed which reads: "Spanish influenza is undoubtedly due to lack of sunshine and fresh air, to dampness out doors and in, and to getting wet feet." This is not quite as amusing as a special telegram to one of the leading Philadelphia papers dated Boston, October 7, which reads thus:

"In connection with the influenza epidemic the directors of the 'Mother' Christian Science Church here announce that the mind is a source of contagion and that elements can contaminate only as diseased images held before the thought and paraded before an excited imagination preliminary to having them expressed on the body through fear and apprehension." Another writer states "The numerous gases used on the battle fields of Europe with their highly poisonous properties, the liberation of large quantities of ground air high in carbon dioxide content due to trench digging and shell holes, the gases from decomposing bodies of men and lower animals, and those set free by the destruction of cities and munition dumps during the last four years may have combined to form a gaseous compound with highly toxic properties probably due to rearrangement of molecules by the tremendous concussion produced by high explosives." With this idea in mind he states, "I am going to advance the theory that the condition termed influenza is in reality a nonbacterial, noncontagious disease caused by the inhalation of small amounts of depressing, highly irritating, high density gas present in the atmosphere, especially at night when the air is surcharged with moisture, more particularly near the surface of the earth." He also states, "The mode of transmission is undoubtedly through the agency of the atmosphere."

The idea that some atmospheric influence or free-from-germ explanation of infections and epidemics was promulgated by Wagner many years ago in his work on pathology under the title of "The Epidemic Constitution of Disease."

Dr. Onodera, of the Society of Internal Medicine of Japan, has laid stress on the meteorologic relation of the occurrence of influenza epidemics, the latter running parallel with the severe cold that returns at about 30-year intervals. There may possibly be some relation of extreme cold periods and crowding.